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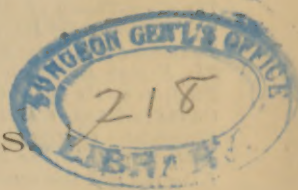
Sanitary Influences
OF
FOREST GROWTH.

Read at a Meeting of the Association,

January 29th, 1885,

—BY—

DR. J. M. ANDERS.



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PAPERS READ BEFORE THE ASSOCIATION.

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SANITARY INFLUENCES OF FOREST GROWTH AND PUBLIC SQUARES.

BY J. M. ANDERS, M. D., PH. D.

THAN the present there could, perhaps, be no more opportune season for making a careful examination of our theme. The public press, as well as scientific writers, not infrequently have been and still are raising a timely cry of warning against the wanton devastation of our primitive forests. That such remonstrances are not needless must become clear to any one who will take the trouble to carefully examine, more particularly the recorded painful experiences of many oriental countries as the result of human improvidence—the physical history of this portion of the globe furnishing numerous examples. To mention only a few of the more striking: Spain, Southern Italy, Persia, Greece, Turkey, and Southern Africa. It is the almost universal experience of tourists that wherever in past time the forests have been cleared away by a people, the effect has been most lamentable, the smaller streams drying up, followed by infertility of the soil, insalubrity of the climate, and frequently utter desolation. To further pursue this line of evidence would be unnecessary, in view of the fact that the writer purposes to bring forward the positive evidences at our command, showing how forests affect conditions of soil and climate.

There is perhaps no element of this subject better understood than the influence which forests exercise mechanically. Clumps or belts of trees act as efficient interceptors of wind currents, affording shelter and protection to humbler vegetation and man to the leeward from the chilly blasts of winter, as well as the drying winds of summer, thus having the effect of modifying extremes of temperature, rendering summer less sultry and winter less severe. In France the experiment has been tried, of planting

trees in belts one hundred metres apart, and with marked benefit to the climate, the happy effect in this instance, being ascribed principally to their mechanical action.

As has been frequently remarked by writers upon the subject, trees in masses or belts, or even heavy shrubbery placed between the originating points of the germs of malaria and human habitations, afford efficient protection from malarial diseases. From the multiplicity of recorded observations by physicians living in malarious districts, this fact may be looked upon as fully proven. Whether this effect is attributable, as most authorities believe, to a mechanical action, or as some have endeavored to show, to a chemico-vital process, is still, perhaps, a moot question. Prof. Austin Flint has remarked that "malaria has an attraction for trees and other organic material." Now it has been recently shown that many species of plants produce ozone, and, as this substance has the power to destroy organic impurities or even disease germs in the atmosphere, it may, with good show of reason, be assumed that, to some extent at least, the germs of malaria are oxidized by the ozone developed by the forest. And may we not in this manner offer an explanation of the so-called affinity of Flint and others, which malaria has for trees and shrubbery? It is, however, highly probable that the influence of trees and humbler vegetation in this regard is largely mechanical. It would be an easy task to give numerous illustrations of the influence of forests in question, as for instance, when the removal of vegetable growth suitably located was followed by malarious diseases in localities where it had been previously unknown, but as this has been frequently done by medical writers it is not deemed necessary here.

During the warm season the temperature of the air of the woods is lower than that of the air outside. This is due partly to the cooling effect of the shade and partly as first pointed out by Petenkofer,* to the slight draught which is always caused by shade in the open air. Again, according to Ebermayer the temperature of the trees of a forest is found to be lower than the air in the forest. There is yet another way in which forests cool the atmosphere. As will appear evident hereafter, one of the chief functions of woods in nature's economy is to maintain a proper

* *Pop. Sci. Monthly*, Feb., 1878.

standard of humidity of the air, and it is well understood that any increase in the humidity of the air reduces the temperature. Dr. Frankland is made to say that he considers the moisture in the atmosphere of England as "reducing the temperature from fifteen to twenty-five degrees."*

Forests are great natural dispensers of moisture. Wherever a fair proportion of woodland exists, a considerable influence is thereby exerted upon the hydrometeorology of the region. This is due to a function actively carried on by plant life in general, viz., transpiration, and its high importance demands a moment's consideration. As the result of careful experimentation, it has been found that a single square foot of leaf surface in the case of soft, thin-leaved plants, will, during fair weather, exhale aqueous vapor at the rate of one and a quarter ounces daily. At night the rate is only about one-fifth as rapid as during the day, and during rainy weather there is absolutely no evaporation. Upon a moment's reflection on the above rate of transpiration, it must become evident that the amount of moisture yielded to the atmosphere by a forest, is really marvelous. In order to give a more definite conception of the vastness of this process, it may be pardonable to introduce here a few deductions, based upon an experimental study of the comparative evaporation from leaves, the soil, and water. 1. It was found that transpiration from the forest was twice as great as from an equal area of open soil, even when the latter was kept moist. 2. That more water is emitted from a forest than from an equal body of water. Under these circumstances it will not be considered an exaggeration to say that there exists a relationship between forest growth and atmospheric humidity.

The old question, do forests in any way influence the rainfall? is not as yet quite satisfactorily determined, a few acute observers claiming their effect in this direction to be entirely negative. But in view of the facts already stated as the result of direct experimentation it cannot be questioned that over and to some extent around the forest the air contains a greater proportion of humidity than is found elsewhere. By a careful computation the writer has been able to demonstrate that not less than half of the rainfall during the summer months, or vegetative period in our

* Dr. Blodget, "Journal Am. Med. Association," Aug. 23, 1884. "Transpiration of Plants," *Amer. Nat.* for March, 1878, by author.

latitude (which would be at least twelve inches), can be accounted for by transpiration, and this, too, where the percentage of woodland is only twenty-five. Add to these facts what has already been intimated as regards the demonstrable variation in the temperature of the forest and the air outside, and it is clear that we have here conditions strongly favoring local precipitation. Furthermore, it seems irresistible to conclude that a warm current sweeping over a country, and striking the cool moist air overhanging and surrounding the forest and mingling with it, would result in condensation. On the other hand, should there come along a stray current of a lower temperature, this same moist canopy would doubtless have a portion of its contained moisture condensed in the form of rain. It should be distinctly understood, it is not claimed for forests that they increase the aggregate annual rainfall, since the total annual evaporation and precipitation bear a constant relation. The effect, then, of woods upon precipitation is local in character, and whilst they do not affect the general course of storms, they are capable of promoting gentle showers, and within certain areas and limits of time influence the amount and distribution of precipitation. Forests also produce abundant dews which shed their enlivening influence to fields and valleys roundabout. When we remember that in some portions of our globe, *e. g.* Egypt and Arabia, nearly all the moisture that reaches the earth is in the shape of dew, it will be conceded that this is no mean office on the part of sylvan nature. Numerous authorities might be cited in confirmation of the above position concerning the effect of woodland upon the rainfall, but time and space forbid.

It is a fact of great importance that transpiration is not governed by the same physical laws as evaporation from soil and water, the chief exciting agent in the former case being the sun's rays, whilst the latter is mainly influenced by temperature and dryness of the air. This implies less variation in the amount of moisture exhaled from vegetation as compared with terrestrial evaporation, and thus *insuring a more uniform standard of humidity in the vicinity of our forests*. There is another fact which lends support to the same view, to wit: that the trees are at all times supplied with a pretty good abundance of moisture for transpiration—owing partly to the power which the roots have to attract moisture from every direction, partly to the retention

of the rainfall in their network of rootlets, to be in due season absorbed by the myriads upon myriads of root hairs. Before dismissing the question of the relation of forests to atmospheric humidity, it seems incumbent to state briefly two minor propositions which, in some degree, affect it: First, that very little, if any moisture, is absorbed by the leaves from the atmosphere. Second, that the evaporations from the soil of the woods is interfered with by the leafy canopy above, which, in a great measure, prevents the rays of the sun from reaching the earth and warming it so as to facilitate the process. Thus it happens that there is only about one-half as much evaporation from forest as from open soil.

The question here naturally arises, does plant humidity differ in any essential particulars from ordinary humidity, or, in other words, has it, regarded from a sanitary point of view, any important advantages over the latter? The fact already intimated that forests supply moisture to the surrounding medium with great regularity, even in time of drought, must be looked upon as having special significance in this connection. As shown by the observations of Prof. Tyndall, the humidity of the air very greatly influences the climate, and more particularly the temperature range. He has conclusively shown that the aqueous vapor in the air has the power to intercept nocturnal terrestrial radiation. When, therefore, the atmosphere contains the proper proportion of moisture, the daily range of temperature is not great, but, on the other hand, it is evident that a low humidity would admit of active radiation, and, in consequence, great nocturnal fall and daily variation in temperature. The greatest objection, it may here be said, to high and dry climes, is this great diurnal range of temperature. From these experiments of Prof. Tyndall, it is clearly established that the great uniformity of forest humidity would insure the most equable climate, with small daily fluctuations in temperature, which, so far as pertains to public health, is of higher importance than the average temperature of seasons.

Forests produce ozone. In a previous article the following, among other conclusions, as the result of numerous experiments, were reached: First, that foliage plants did not generate ozone. Secondly, that all flowering vegetation was capable of generating this substance.* Subsequently, additional experiments proved

* The Exhalation of Ozone by Flowering Plants. *Amer. Nat.*, April and May, 1884.

that the conclusions arrived at in the article here cited must be so modified as to include among ozone-generating plants those which, though not flowering, have *odoriferous* foliage. Branches taken from the pine-tree and the hemlock spruce (*Abies Canadensis*), were found to be active generators of this substance. There is, to a great degree, a confirmation of these researches in the observations of Dr. Nicholson, who found ozone more abundant in pine forests than the open country in summer, but less abundant in winter;* also in the statement of Dr. Schrieber, of Vienna, to wit, that the terebinthinate vapors exhaled by coniferous plants, possess, to a greater degree than any other known substance, the power of converting the oxygen of the air into ozone.† It cannot be questioned but that ozone is the chief natural purifying agent of our atmosphere from all organic matter.

As already incidentally intimated, the atmosphere of the pine and hemlock forests is impregnated with balsamic vapors. The observation has also been made that children playing among our common poppy plants will exhibit signs of the physiological action of opium. In view of such demonstrable facts there can be no doubt of the correctness of the view elsewhere expressed; that it is quite reasonable to conclude, that with the rapid transpiration of aqueous vapor from a tree or plant as shown by our investigations, there are peculiar to the species, active principles, which also assume the gaseous form and are held in solution by the moist vapors given off.‡ Plant humidity, therefore, it will be concluded, differs vastly from that derived from dead organic matter, the soil, or bodies of water, since it is changed, purified and probably endowed with medicinal properties in passing through the vital laboratory of the plant.

In the next place let us consider the influences of forests upon the soil and running streams. It is a noteworthy fact that many of our smaller streams and rivulets owe their origin and permanence to forests. It has been incontestably shown by a host of observers, that where forests have been cleared away springs and smaller streams have quickly dried up, and have reappeared after re-afforesting the same districts. Again, in a perfectly con-

* Michigan Health Board Report.

† Address before the Austrian Meteorological Society.

‡ "Relation of Forests to Health Resorts," *Phila. Med. Times*, May, 1884, by the author.

servative spirit, the same conclusion will be arrived at by thinking of the matter from a different standpoint, and considering how they act in producing this effect. Very much after the fashion of a sponge do the roots and meshes formed by the network of small rootlets entangle and retain the rainfall, preventing it from running off quickly into the streams, thus resulting in frequent freshets, to be followed by periods of drought. The influence of woods in preserving an equable supply and distribution of water is of great hygienic importance.*

The influences which forests exert upon the soil are highly important, but frequently misunderstood. From what has already been adduced as relating to the effects of forests upon local climatic elements and running streams it may justly be concluded that they do preserve a more uniform degree of moisture in the soil in their vicinity. It is usually asserted by writers upon the subject that the soil of the forest is more humid than open soil. The explanation of this is to be found in the well-known facts, that its temperature is lower on account of not being exposed to irradiation, and that the covering of fallen leaves acts mechanically in preventing the escape of moisture.

Under other conditions, as when located in marshy districts, forest growth has a decided drying effect upon the soil. This can be explained by the extremely active transpiration by the leaves of the trees. This process goes on at the same rate so long as there is moisture at hand, in this manner soon getting rid of the redundancy, especially during dry periods of time. Again the trunks and branches act as large reservoirs for the storage of a great part of the rainfall, which is drunk up by the roots almost as soon as precipitated. It would therefore be expected, from these considerations, that low marshy ground would be rendered drier by the cultivation of trees in due proportion, and there are recorded familiar observations of a practical kind to bear out this idea.

Mr. D. Howitz, Forest Conservator of Denmark, in a parliamentary report on the resources and need of Ireland for forest cultivation observes, "that swamps and morasses are created in Ireland from the want of trees to drink up the superfluous moisture." According to the observations of Gimlet in Algeria,

* Their action in this particular direction likewise has a marked effect upon the industrial arts and productive resources of a region.

extremely malarious districts have been rendered quite harmless, in four or five years, by the absorbent action of, and evaporation from, the *eucalyptus globulus*. The efficacy of forests in preventing inundations and the washing away of superficial strata of soil, causing erosions and even deep ravines, should be mentioned as however affecting chiefly agriculture and other industries of civilized life.

From the various climatic and terrestrial influences of forest growth that have been considered, it is quite clear that they exert a potent influence upon the salubrity and healthfulness of a locality. The woodland air is highly invigorating, as evidenced by the happy results of camp-life in the wilderness, and the benefit derived by "run down" subjects from leading an active nomadic life among our forests, at low or moderate elevation. Forest trees and plantations have an æsthetic influence. The impressions they make upon the organs of sense, serve admirably to relieve mental tension, and agreeably entertain the mind. And thus practical experience agrees entirely with what would be expected from our knowledge of the character of forest air, viz.: that it is a more or less humid atmosphere, charged with principles possessing therapeutic properties, and containing that highly important substance, ozone. It ought to be here stated that the proper ratio of woodland, for ordinary sanitary purposes, is not less than twenty-five per cent. And since the effects of woods upon the air are limited in area, their proper distribution, so as to improve the whole body of the atmosphere to an equal degree, becomes a matter of the greatest moment.

Having shown that forests have a considerable influence upon the degree of saturation of the air, it follows that in conditions of ill-health requiring for their treatment a more or less humid air, forest growth in due proportion would serve the purpose admirably. They must, therefore, be capable of rendering energetic and valuable service in connection with health-stations. Now, as to the value of atmospheric moisture in the treatment of invalids, and particularly that large and unfortunate class—consumptives, there is great diversity of opinion. Doubtless, however, the majority of authorities have pronounced in favor of high altitudes over the lower, moister climes, in consumption. It should be recollected that the air of the forest cannot be spoken of as containing excessive humidity, and we have experi-

mental data to bear out the correctness of this view. The observations of L. Fautial and A. Sartioux, pertaining to this point, will justify a citation. "We now made the following observations in the heart of the forest of Helatte, which embraces 5000 hectares of land. At the height of about 6 metres (20 feet), above a group of oaks and hornbeams 8 or 9 metres, we placed a pluviometer, psychrometer, maximum and minimum thermometers, and an evaporator, so as to ascertain at that point the amount of rainfall, the degree of saturation of the air, and the temperature and evaporation. In open air, at a distance of only 300 metres from the forest, and at the same height above the ground as in the former case, we placed similar instruments, under the same conditions. With regard to the rainfall and degree of saturation, the observations for six months showed the total rainfall to be 192.50 mm. in the forest, and 177 mm. in the open air; difference in favor of the forest, 15.50 mm. The degree of humidity for the open air showed a mean of 61.7°, and in the forest 63°; difference in favor of the forest, 1.3°."

According to these experiments, the relative humidity over this extensive forest is somewhat greater than outside; still, the excess is not great enough upon which to found a reasonable objection to the presence of a fair percentage of forest growth at health resorts, excepting perhaps where an extremely dry climate is desirable. Moreover, by careful attention to the character of the vegetation, and percentage of woodland, and elevation, the degree of saturation of the atmosphere desired could be attained. Thus at a resort of medium altitude, not more than fifty per cent. of forest area would produce an effect suited to cases of phthisis requiring a comparatively dry climate, since the small increase in humidity thereby occasioned would be more than counterbalanced by other beneficial influences already mentioned, such as the generation of ozone, the mechanical effects in protecting from malaria and objectionable wind-currents, besides minor influences, which act as valuable adjuvants. Attention may be very briefly called to some of the conditions that would receive benefit in an atmosphere of the above character, viz.: the earlier stages of chronic phthisis, as it is most generally encountered; catarrhal forms of the disease, with marked inflammatory action extending along the laryngeal and bronchial mucous membranes, seen most frequently in cold, raw climates, and

having their origin usually in "taking cold," as well as cases of chronic bronchitis and laryngitis. In those predisposed by inheritance to lung disease, a residence in an atmosphere such as just described, would prove a most powerful prophylactic measure. The practical value of plant exhalations, as preventive agents in consumption, as well as the healthful practice of cultivating plants, both indoors and out, have been elsewhere discussed.*

There are in the United States numerous delightful resorts with a proportion of forest growth suitable for the above category of patients, both during the summer and winter seasons. Without stopping to describe any particular resorts, it may suffice to say that they are to be found through the northwestern States of Minnesota, Wisconsin, Colorado and Nevada; or, starting from the northern coast line of New England, and passing in a southerly direction we see them in New York, Pennsylvania (in good numbers), Virginia, and through the Carolinas. Should his strength admit of it, a patient having any of the conditions above described should be recommended to spend an active moving life, making frequent woodland excursions, since exercise is highly essential to realize the greatest benefit from the pure, vitalizing forest air.

It is an important observation that from the structural peculiarities of the pine leaves being dense and having a thick cuticular covering, the function of transpiration is carried on at about one-third of the rate as from forest trees having soft thin leaves, so that the effect of the pine woods upon the degree of saturation of the air is actually very slight, and hence they can scarcely be said to be open to the same objections in this regard as other forests, even though the percentage of woodland should be very high. Besides, as has been seen, the pine exhalations are among the chief natural agents which produce ozone, and what is not unimportant, the pine-tree flourishes well in dry, sandy soil. It follows from all this that in all the various conditions of phthisis in whose treatment the element of dryness is indicated, the air of the pine grove on an elevation offers advantages superior to those of forests composed of different other species. Fortunately pine forests are not infrequently found to be so highly favorably situated, *e. g.*, Roan Mountain, North Carolina, has an elevation

* House Plants and Lung Disease. Trans. Med. Soc. Penna., 1883, by author.

of 6394 feet, and is covered with vegetation almost to its summit. Near the base of the mountain are found the walnut, oak, maple, gum, poplar, magnolia, and other species, whilst in the higher regions evergreens, spruces, and pines abound. The practical value of pine groves in the treatment of consumptives is well-established.*

There is a smaller class of phthisical patients where a more humid air is not only more grateful, but also more beneficial. To this class belong those patients having a highly sensitive nervous system, and those who are sometimes yet in the second, but more frequently in the third or last stage of the affection. A resort having a profusion of forest growth, not less than from sixty to eighty per cent., at some well-sheltered spot at low elevation in a warm or temperate climate would meet the requirements of the present group of sufferers. They are usually far advanced as regards the local lesions, and having a disease of mortal character it would be far better, if convenient, to send them to the nearest retreat of this kind, than to advise a change to some distant resort of note, or, as is but too frequently the case, recommend the almost cruel practice of expatriation, with all its attendant inconveniences.

No attempt is here made to distinguish between all of the various forms of consumption of the lungs, and to indicate the particular resort required for their climatic treatment; on the contrary, the object is to simply sketch a general outline of the subject. Besides being useful to consumptives, the forest air, it is stated by Dr. Oswald,† relieves scirrhus affections of the skin. The same author quotes Dr. Boehm, who has observed that "ophthalmia and leprosy, which have become hereditary diseases, not only in the valley of the Nile, but in the table lands of Barca and Tripoli are utterly unknown in the well-timbered valley of Abyssinia, though the Abyssinians live more than a hundred geographical miles nearer to the equator than their afflicted neighbors."

Since our public squares may be looked upon as forests of reduced size, it is desired to call brief attention to their effects upon the air of cities. It must be confessed that nowhere could

* Reports of cases in which pine woods have been highly serviceable, must be omitted.

† *Pop. Sci. Monthly*, August, 1877.

trees and ornamental shrubbery prove their virtues to greater advantage to the public health than by improving the conditions of a vitiated city atmosphere. As in the case of forests, the action of public grounds must needs be of a local character, hence it is quite obvious that in large cities quite a number of squares of the size of those in Philadelphia, would be needed to produce the desired effect. The conclusions respecting the influence of forests upon local climate apply with few exceptions of little importance in the present instance. For obvious reasons, their effect in mitigating extremes of temperature, by checking the force of wind currents is here almost negative, but the trees, by causing refreshing shade and transpiring aqueous vapor, have a delightful cooling effect, thus tending to moderate the oppressive midsummer heat of our large cities. Along with the moist vapors constantly emitted there are also other health-giving principles evolved, and among them ozone is, perhaps, the most important. Since only the flower and odoriferous foliage are ozone generating, the vegetation of these public parks should be selected with due regard to this fact. The same percentage of the total area should be assigned for retreats of this kind, as was indicated when speaking of the proper ratio of woodland for ordinary sanitary purposes, viz., twenty-five. But what city can boast of such a percentage of forest area? This would also be manifestly impossible in those portions of older cities already densely built up, but even here a nearer approach to the proper standard might be attained by the general planting of trees on either side of our thoroughfares. This latter suggestion, if carried out, would have the effect of improving the air of our streets—which is really the air we breathe—and thus by means of free ventilation a purer and wholesomer atmosphere would be admitted into our dwellings.

It is quite evident, that by providing sufficient reservations of this sort a perfect boon would be conferred upon that large element of our population, the humbler classes, who, for financial reasons are unable to make a change of residence during the heated term. Again, such squares form a convenient substitute for a more complete change of air in the cases of that large class of little patients suffering from infantile diseases of summer.

Who can question but that the lives savable by the maintenance of a sufficient number of these public parks could be counted by tens of thousands? For in all medical knowledge there is no

fact better established than that the usual summer ailments of infants can be most successfully treated by a change of air. Than the subject of open squares and their keeping up under proper regulations, there is none more important, inviting the attention of our municipal law makers, and it is no exaggeration to say that any improvements they might make in this regard would be rewarded by a realizing sense of having done the greatest good to the greatest number.
